Sustainable
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Landscapes

Understanding the Effects of Flooding on Trees

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Tree Tolerance to Flooding

A frequently asked question during the summer of 1993 as torrential rains and overflowing rivers plagued much of the Midwest was “how long will trees tolerate flooding before injury results?” Unfortunately, it is difficult to answer this question precisely since environmental conditions associated with flooding are poorly understood, and individual trees, even those within the same species, may respond differently to flooding (Fig. 1). An understanding of soil, tree, and flood characteristics will help tree managers cope with this problem and prepare for future floods.

Flooding and Stress Symptoms

Flooding during the growing season typically is more harmful to trees than flooding during dormant periods. And, the longer trees are exposed to flooding, the greater the potential for injury. Short periods of flooding during the growing season can be tolerated by most trees, but if flooding is recurrent or uninterrupted and keeps soils saturated, serious damage to trees may occur. Flood-stressed trees exhibit a wide range of symptoms including leaf chlorosis (yellowing), defoliation, reduced leaf size and shoot growth, epicormic sprouting (sprouts along the stem or trunk), and crown dieback. Early fall coloration and leaf drop often occur (Fig. 2), and large seed crops may appear on stressed trees in the growing season after flooding. These symptoms may progress into tree decline and death, reoccur for several years and then eventually disappear, or subside as early as the next year indicating rapid tree recovery.

Effects of Flooding on Soils

Flooding reduces the supply of oxygen to the soil and roots and usually results in growth inhibition and injury to flooded trees. The deposition of sediments during flood conditions also contributes to poor soil aeration. Deposits of silt or sand as shallow as three inches can be injurious, especially to newly planted trees. Tree roots also must contend with high concentrations of toxic compounds like alcohol and hydrogen sulfide (rotten-egg gas) that accumulate in waterlogged soils. Finally, strong currents and soil particles suspended in flood waters can erode soil from around the base of trees, exposing tree roots (Fig. 3). Exposed roots are vulnerable to drying and mechanical injury, and their occurrences may make trees more vulnerable to windthrow.

Effects of Flooding on Trees

Tree injury increases in proportion to the amount of crown covered by water. Many tree species can survive months of flooding as long as their canopies remain above the water. But when foliage is completely submerged, death may occur in less than one month. This is particularly noticeable on conifers when lower branches covered by flood water die after only a few days of submersion. Mature, well-established trees are more tolerant of flooding than overmature trees or seedlings of same species, and vigorous, healthy trees withstand flooding better than trees that were already under stress. (Fig. 4)

Below-ground studies show long-term flooding can lead to death and decay of large portions of a tree's root system. Flood-sensitive species unable to produce new roots after flooding quickly die, whereas roots of flood-tolerant trees either survive flooding in an active or dormant condition, or they regenerate from the root collar or trunk near the water surface. The biology of flood tolerance is poorly understood, and studies conducted to determine flood tolerance have resulted in contradictory conclusions. Still, it is generally accepted that some tree species show greater tolerance to flooding than others (Table 1).

Table 1. Relative tolerance of trees to flooded or waterlogged soil.

Tolerant

Acer rubrum - red maple
Fraxinus nigra - black ash
Fraxinus pennsylvania - green ash
Larix laricina - Eastern larch
Salix nigra - black willow
Taxodium distichum - baldcypress

Intermediate

Abies balsamea - balsam fir
Acer negundo - boxelder
Acer saccharinum - silver maple
Alnus rugosa - speckled alder
Betula nigra - river birch
Celtis occidentalis - hackberry
Fraxinus americana - white ash
Gleditsia triacanthos - honeylocust
Liquidambar styraciflua - American sweetgum
Platanus occidentalis - sycamore
Populus deltoides - Eastern cottonwood
Populus tremuloides - quaking aspen
Pyrus calleryana - callery pear
Quercus macrocarpa - bur oak
Quercus palustris - pin oak
Quercus phellos - willow oak
Salix alba - white willow
Thuja occidentalis - Eastern arborvitae
Ulmus americana - American elm

Intolerant

Acer platanoides - Norway maple
Acer saccharum - sugar maple
Aesculus flava - yellow buckeye
Asimina triloba - common pawpaw
Carpinus caroliniana - American hornbeam
Carya ovata - shagbark hickory
Cercis canadensis - Eastern redbud
Cladrastis kentukea - American yellowwood
Crataegus x lavallei - lavalle hawthorn
Fagus grandifolia - American beech
Juglans nigra - black walnut
Juniperus virginiana - Eastern red cedar
Liriodendron tulipifera - tulip tree
Magnolia x soulangiana - saucer magnolia
Malus - crabapple
Nyssa sylvatica - black gum
Ostrya virginiana - American hophornbeam
Picea abies - Norway spruce
Picea glauca - white spruce
Picea pungens - Colorado spruce
Pinus bansiana - jack pine
Pinus resinosa - red pine
Pinus strobus - Eastern white pine
Prunus serotina - black cherry
Quercus alba - white oak
Quercus muehlenbergii - chinkapin oak
Quercus rubra - red oak
Sassafras albidum - sassafras
Sorbus aucuparia - European mountainash
Tilia - linden
Tsuga canadensis - Eastern hemlock
Ulmus pumila - Siberian elm

(Source: Sinclair, Lyon, and Johnson, 1987)

Insects and Diseases

Flood-stressed trees are prime candidates for attack by "secondary organisms." Several opportunistic disease-causing fungi and insects invade trees that are weakened or stressed.

A group of fungi called the water molds, including *Phytopthora* and *Pythium*, can attack trees only when the soil is saturated or nearly saturated. Fungal spores swim through the soil water and invade the tree, causing the roots or crown to turn brown and become wet and decayed. The first indication of damage may be yellowing or falling of leaves, dieback of limbs, or failure to leaf-out in the spring. Another group of fungi causes cankers (areas of killed, discolored bark) on branches and trunks of weakened or stressed trees. Flooding, drought, and premature defoliation impair tree defense mechanisms and trigger biochemical responses that release carbohydrates, sugars, and other nutrients which seem to invite insect and fungal pathogen attack. Because canker fungi typically won't attack trees that are not already weakened, they are sometimes called "secondary attackers." Both water molds and canker fungi are most damaging to flood-intolerant tree species planted on poorly drained, clay soils or on sites flooded for prolonged periods. Their effects may have become apparent during 1993, or may appear several years later. The best strategy in dealing with potentially flood-stressed trees is to minimize additional stress or injuries to allow the maximum chance for natural recovery.

Stem boring insects such as phloem borers and wood borers are the major "secondary" insects of concern. Phloem borers damage portions of the tree responsible for food and water transport. Wood borers feed within the wood of tree stems and branches causing them to weaken and break during ice, wind, or snow storms. Minimizing additional stress or injuries should be a priority on high-value trees for 1 to 3 years after flooding to reduce the chance of attack by insects.

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Managing Flood-stressed Trees

The 1993 floods in Iowa were very unusual in that
(1) trees were submerged for long periods (months in some cases),
(2) flooding occurred during the growing season, and
(3) urban and non-floodplain trees were affected as well as floodplain trees.

Very little is known about the effects of long-term flooding during the growing season on many ornamental tree species. In fact, the full impact of flooding may not be known until the year after flooding at the earliest! Severe cold arriving unseasonably early, an exceptionally harsh winter, or a reoccurrence of flood conditions in subsequent years may push some trees, already suffering from the effects of flooding, into irreversible decline.

The best approach to managing flood-stressed trees is to enhance their vigor by following proper tree-maintenance practices and eliminating additional stresses. Dead or severely cankered branches should be removed as soon as possible. Other corrective pruning should be delayed until the late dormant season. Applying a low-nitrogen fertilizer, aerating the soil, mulching, and watering during extended dry periods are recommended tree-care practices that can help enhance vigor, but they are not rescue treatments for severely injured trees. Trees developing substantial dieback and decline symptoms or those possessing defects that decrease their structural integrity, making them more prone to windthrow and structural failure, should be removed from the landscape immediately. Looking to the future, only tolerant species like bald cypress should be planted in areas prone to flooding or to prolonged waterlogging of the soil (Fig. 5).

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